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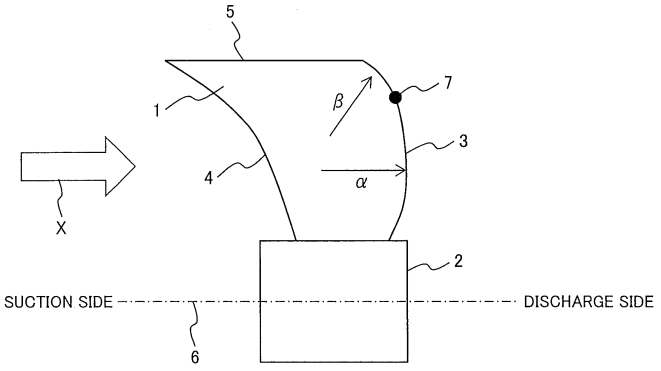
(54) PROPELLER FAN AND AIR CONDITIONER EQUIPPED WITH SAME

(57) In order to suppress that a velocity in the vicinity of a bell mouth is lowered to induce non-uniformity in velocity at an outlet of a blade and an outlet of the bell mouth caused by adoption of a forward-swept blade which makes a tip vortex small as means for noise reduction, in a blade of a propeller fan, a trailing edge portion which has been rotationally projected on a plane passing through a rotational axis is formed from the rotational axis toward a blade tip portion so as to bend from the suction side to the discharge side with a first curvature, and is further formed so as to bend with a second curvature which is smaller than the aforementioned first curvature with an inflection point interposed.

FIG. 1



EP 2 960 525 A1

Description

Technical Field

[0001] The present invention relates to a propeller fan and an air conditioner equipped with same.

Background Art

[0002] The propeller fan is applied to the air conditioner and so forth in many cases. Fig. 13 shows a plan view of a propeller of a conventional propeller fan. Fig. 13 is a diagram viewing the propeller from the discharge side. The propeller is configured by a plurality of blades provided around a hub. There are many cases where the blade of a shape (a forward-swept blade) which makes the blade advance in a rotation direction is adopted, aiming at noise reduction. The forward-swept blade has an action of making a tip vortex which flows out from the blade tip small and has an effect of reducing noise.

[0003] As the background art of the present technical field, there is Japanese Examined Patent Publication No. Hei2-2000(Patent Literature 1). In Patent Literature 1, it is described that air flow rate enlargement, static pressure heightening and noise reduction can be made by numerically limiting shape parameters such as a degree of sweep of the blade and an inclination of the blade, a camber of the blade section and so forth of the above-mentioned forward-swept blade.

[0004] In addition, there is Japanese Patent No. 3744489 (Patent Literature 2). In Patent Literature 2, it is described that the noise can be reduced by making the tip vortex small by curling an outer peripheral end part of the blade toward the suction side. Further, it is also described that the noise can be reduced by suppressing interaction between an air flow and the bell mouth by defining a positional relation between such blade and bell mouth.

[0005] Further, there is Japanese Patent No. 4818184 (Patent Literature 3). In Patent Literature 3, it is described that the tip vortex is migrated into a blade tip part by warping the blade toward the suction side by a definition method different from that in Patent Literature 2 so as to prevent interaction between the tip vortex and the bell mouth and thereby noise reduction and efficiency heightening can be made.

Citation List

Patent Literature

[0006]

PTL 1: Japanese Examined Patent Application Publication No. Hei2-2000
PTL 2: Japanese Patent No. 3744489
PTL 3: Japanese Patent No. 4818184

Summary of Invention

Technical Problem

[0007] In an embodiment, force that a blade acts on a flow will be referred to as "blade force". The blade force that the blade acts on the flow is shown by an arrow A' in Fig. 13. In a propeller of a conventional propeller fan, since the blade has a shape which has forward sweep in the rotation direction, the blade force acts so as to direct in an inner radial direction relative to a direction of the rotational axis 6 just like the arrow A'. Since the flow obtains a momentum directed in the inner radial direction by this blade force directed in the inner radial direction, the flow is directed in the inner radial direction.

[0008] A schematic diagram of a velocity vector which has been projected on a section passing through a rotational axis 6 in the conventional propeller fan is shown in Fig. 14. As shown in Fig. 14, since the flow is directed in the inner radial direction, the flow will not be supplied to the vicinity of the bell mouth which is arranged so as to cover an outer periphery of the propeller fan, though not shown. Then, a velocity of air in the vicinity of the bell mouth is lowered. When the flow is not supplied to the vicinity of the bell mouth, velocities at the outlet of the blade and the outlet of the bell mouth become non-uniform, it was the problem in view of heightening the efficiency of the propeller fan.

[0009] Accordingly, the present invention aims to promote heightening of the efficiency of the propeller fan.

Solution to Problem

[0010] In order to solve the above-mentioned problem, configurations, for example, described in Claims are adopted.

[0011] Although the present application includes a plurality of means for solving the above-mentioned problem, when one example thereof is given, a propeller fan includes a rotational axis serving as a center of rotation and a plurality of blades provided around the rotational axis, a bell mouth being arranged outside in an outer radial direction of the plurality of blades, wherein each of the plurality of blades is formed by a trailing edge portion formed on the rear relative to a rotation direction, a leading edge portion formed on the front relative to the rotation direction, a blade tip portion formed from a tip portion in an outer radial direction of the trailing edge portion toward a tip portion in an outer radial direction of the leading edge portion, the aforementioned trailing edge portion which has been rotationally projected on a plane passing through the aforementioned rotational axis is formed from the aforementioned rotational axis toward the aforementioned blade tip portion so as to bend from the suction side to the discharge side with a first curvature, and is further formed so as to bend with a second curvature which is smaller than the aforementioned first curvature with an inflection point interposed.

[0012] In addition, in the above-mentioned configuration, it is desirable that on end face of the aforementioned

bell mouth which is closest to the aforementioned blade, a position which is an end portion in a discharge direction and where an angle is changed in an outer radial direction almost match a position of the aforementioned inflection point, viewing from above a rotation plane.

[0013] In addition, in the above-mentioned configuration, it is desirable that the aforementioned trailing edge portion which has been rotationally projected on a plane vertical to the aforementioned rotational axis be formed to be convex in a reverse rotation direction from the aforementioned rotational axis toward the aforementioned blade tip portion, and be formed linearly or to be convex in the rotation direction with the inflection point interposed.

[0014] In addition, in the above-mentioned configuration, it is desirable that, each of the aforementioned plurality of blades is, a blade force act on a portion formed with the aforementioned first curvature in the aforementioned trailing edge portion so as to direct in an outer radial direction relative to a direction of the aforementioned rotational axis and a blade force act on a portion formed with the aforementioned second curvature in the aforementioned trailing edge portion so as to direct in an inner radial direction relative to the direction of the aforementioned rotational axis.

[0015] In addition, in the above-mentioned configuration, it is desirable to include a guard which lets air pass toward the discharge side of the aforementioned blade, prevents mixing of a foreign material which exceeds a predetermined size and is apart from the propeller with a distance exceeding a predetermined length.

[0016] Further, it is desirable that, in an air conditioner which includes a housing having a suction port and a discharge port of air, a heat exchanger arranged in the housing and a fan which is arranged upstream or downstream of the heat exchanger and sucks air on the outside of the housing through the aforementioned suction port and discharges it through the aforementioned discharge port, the propeller fan described in any of the above-mentioned configurations be used as the fan.

Advantageous Effects of Invention

[0017] According to the present invention, efficiency heightening of the propeller fan can be implemented.

Brief Description of Drawings

[0018]

[Figure 1] Fig. 1 is a sectional diagram of a plane passing through a rotational axis of a propeller fan of an embodiment 1.

[Figure 2] Fig. 2 is a diagram explaining a difference in blade force between the propeller fan of the embodiment 1 and a related art propeller fan.

[Figure 3] Fig. 3 is a schematic diagram of a velocity vector which has been projected on a section passing through the rotational axis of the propeller fan of the embodiment 1.

[Figure 4] Fig. 4 is a sectional diagram of a plane passing through a rotational axis of a propeller fan of an embodiment 2.

[Figure 5] Fig. 5 is a schematic diagram of a velocity vector which has been projected on a section passing through the rotational axis of the propeller fan of the embodiment 2.

[Figure 6] Fig. 6 is one example of comparison in shaft power of the propeller fan in the embodiment 2 with a conventional propeller fan.

[Figure 7] Fig. 7 a diagram showing a combination with a bell mouth of the shape which is different from that in Fig. 4 in the embodiment 2.

[Figure 8] Fig. 8 is a diagram showing a combination with a bell mouth of the shape which is different from that in Fig. 4 in the embodiment 2.

[Figure 9] Fig. 9 is a plan view of a propeller in an embodiment 3.

[Figure 10] Fig. 10 is a diagram of a propeller fan in an embodiment 4.

[Figure 11] Fig. 11 is one example of comparison in noise of the propeller fan in the embodiment 4 with the conventional propeller fan.

[Figure 12] Fig. 12 is a sectional diagram of an air conditioner in an embodiment 5.

[Figure 13] Fig. 13 is a plan view of a propeller of the conventional propeller fan.

[Figure 14] Fig. 14 is a schematic diagram of a velocity vector which has been projected on the section passing through the rotational axis in the conventional propeller fan.

Description of Embodiments

[0019] In the following, embodiments of the present invention will be described using the drawings.

Embodiment 1

[0020] An embodiment 1 of the present invention will be described using Fig. 1 to Fig. 3.

[0021] Fig. 1 is a sectional diagram of a plane passing through a rotational axis of a propeller fan of the embodiment 1. 1 is a blade, 2 is a hub, 3 is a trailing edge portion, 4 is a leading edge portion, 5 is a blade tip portion, 6 is the rotational axis serving as the center of rotation, X shows a flow direction of air. The trailing edge portion 3 is formed on the rear relative to a rotation direction of the blade 1, the leading edge portion 4 is formed on the front relative to the rotation direction of the blade 1. The blade tip portion 5 is formed from a tip portion in the radial direction concerned of the trailing edge portion 3 to a tip portion in the radial direction concerned of the leading edge portion 4.

[0022] In Fig. 1, the trailing edge portion 3 which has been rotationally projected on a plane passing through the rotational axis 6 is shown. The trailing edge portion 3 is formed from the rotational axis 6 toward the blade-

tip portion 5 so as to bend from the suction side toward the discharge side with a first curvature α. Further, it is formed so as to bend with a second curvature β which is smaller than the first curvature α with an inflection point 7 interposed.

[0023] Fig. 2 is a diagram explaining a difference in blade force between the propeller fan of the embodiment 1 and a related art propeller fan. Fig. 2 is the diagram viewing the propeller fan from the discharge side diagonally. A shows a blade force that a part 3b of the second curvature β of the trailing edge portion 3 of the propeller fan of the embodiment 1 acts. A' shows a blade force that a trailing edge portion 3b' on the side of a blade tip portion 5' of the related art propeller fan acts. Y shows a rotation direction of the blade.

[0024] Since the blade 1 of the propeller fan of the present embodiment is of the above-mentioned configuration, the blade force A acts so as to direct in an outer radial direction relative to a direction of the rotational axis 6. Therefore, a flow in the vicinity of the trailing edge portion 3b comes to obtain a momentum which would partially direct in the outer radial direction relative to the direction of the rotational axis 6. On the other hand, the blade force A' of the conventional propeller fan acts so as to direct in an inner radial direction relative to the direction of the rotational axis 6. Therefore, a flow between blades obtains a momentum which would direct in the inner radial direction relative to the direction of the rotational axis 6.

[0025] A schematic diagram of the velocity vector which has been projected on the section passing through the rotational axis in a conventional propeller fan is shown in Fig. 14. A flow T in Fig. 14 obtains a momentum directing in the inner radial direction by the blade force A' which directs in the inner radial direction relative to the direction of the rotational axis 6 in Fig. 2 and thus comes to direct in the inner radial direction. Therefore, though not shown, the flow is not supplied to the vicinity of the bell mouth which is arranged so as to cover the outer radial direction of the propeller fan and the velocity in the vicinity of the bell mouth is lowered. That the flow is not supplied to the vicinity of the bell mouth means that it will stagnate just like a flow U. Then, the velocity on the outlet side of the blade becomes non-uniform due to the flow U in the vicinity of the bell mouth and the flow T and it could be a factor of efficiency lowering.

[0026] A schematic diagram of a velocity vector which has been projected on a section passing through the rotational axis in the propeller fan of the embodiment 1 is shown in Fig. 3. The flow in the vicinity of the blade tip portion 5 comes to direct by the action of the bade force in Fig. 2 in the outer radial direction relative to the rotational axis 6 just like a flow S in Fig. 3. That is, according to the shape of the trailing edge portion 3 of the present embodiment, the blade force A acts on a part which is formed with the first curvature α in the trailing edge portion 3 so as to direct in the outer radial direction relative to the direction of the rotational axis 6 and the blade force acts on a part which is formed with the second curvature β in the trailing edge portion 3 so as to direct in the inner radial direction relative to the direction of the rotational axis 6.

[0027] Consequently, while, conventionally, the flow has stagnated just like the flow U not being supplied to the vicinity of the bell mouth as shown in Fig. 14, it is possible to suppress a situation where the flow U is generated by the action of the blade force A as observed conventionally. Therefore, since the velocity in the vicinity of the blade outlet can be made uniform and a mixing loss of a blade wake is reduced, it becomes possible to increase the efficiency.

Embodiment 2

[0028] In the present embodiment, an embodiment which can make the embodiment 1 more highly efficient will be described using Figs. 4 to 8.

[0029] Fig. 4 is a sectional diagram of a plane passing through the rotational axis of a propeller fan of an embodiment 2. 8 is a bell mouth, 9 is a cylindrical portion, 10 shows an end portion of the bell mouth. The cylindrical portion 9 is a portion of the bell mouth 8 and covers the blade 1 with a predetermined clearance interposed. The end portion 10 is an end portion on the discharge side of the cylindrical portion 9, and the end portion 10 is arranged so as to match the inflection point 7, viewing from above the rotation plane, as a position where the angle is changed to a right angle in the outer radial direction in Fig. 1.

[0030] That is, on an end face of the bell mouth 8 which is closest to the blade 1, it is made such that the position which is the end portion 10 in a discharge direction and where the angle is changed to the outer radial direction almost matches the position of the inflection point 7, viewing from above the rotation plane. Thereby, on the end face of the bell mouth 8 which is closest to the blade 1, the position which is the end portion 10 in the discharge direction and where the angle is changed to the outer radial direction almost matches a position serving as a boundary between a portion to which the outward blade force A acts and a portion to which the outward blade force A does not act, viewing from above the rotation plane.

[0031] A schematic diagram of a velocity vector which has been projected on a section passing through the rotational axis in the propeller fan of the embodiment 2 is shown in Fig. 5. Since the end portion 10 and the inflection point 7 are arranged so as to almost match mutually, a velocity distribution which has been made uniform by the action of the blade force in the arrow A direction shown in Fig. 2 in the embodiment 1 is maintained with no dispersion of the flow by the cylindrical portion 9. Therefore, the operational effect of the embodiment 1 can be more surely obtained and the efficiency of the propeller fan can be increased.

[0032] A result of comparison in shaft power of the pro-

peller fan in the embodiment 2 with the conventional propeller fan is shown in Fig. 6. In the vicinity of an operating point, the power consumption of the propeller fan of the embodiment 2 is energy-saved by 3.3% in comparison with the conventional propeller fan, that is, efficiency heightening is obtained.

[0033] Fig. 7 and Fig. 8 are diagrams showing combinations with bell mouths of shapes different from that in Fig. 4 in the embodiment 2. The bell mouth in Fig. 7 is arched on the discharge side of the cylindrical portion 9. In this case, an end portion 10a serves as a contact point between a straight line and an arch of the cylindrical portion 9. The bell mouth in Fig. 8 is conically tapered on the discharge side of the cylindrical portion 9. In this case, an end portion 10b serves as a contact point between the straight line and the conical taper of the cylindrical portion 9. As shown, the end portions 10a and 10b are arranged so as to match the inflection point 7, viewing from above the rotation plane. The operational effect obtained by the present invention is, the same advantageous effect as that of the bell mouth in Fig. 4 can be obtained also in any of the bell mouths in Fig. 7 and Fig. 8.

Embodiment 3

[0034] In the present embodiment, an embodiment which can make the embodiment 1 or the embodiment 2 more highly efficient will be described using Fig. 9 and Fig. 10.

[0035] Fig. 9 is a plan view of a propeller in an embodiment 3. Fig. 9 is the diagram that the propeller has been viewed from the discharge side. In Fig. 9, the trailing edge portion 3 is projected on a plane which is vertical to the rotational axis. The trailing edge portion 3 is formed into a convex shape in a reverse rotation direction from the hub 2 toward the blade tip portion 5 and is formed to be convex in the rotation direction with an inflection point 18 interposed. B is a blade force that the vicinity of a trailing edge portion 3h on the hub 2 side acts, C shows a blade force that the vicinity of a trailing edge portion 3t on the blade tip portion 5 side acts. It is desirable that the inflection point 18 have the same radius as the inflection point described in the embodiments 1 and 2.

[0036] Since the curvature of the trailing edge portion 3t has been changed with the inflection point 18 set as a boundary, the orientation of the blade force C is changed to the outer radial direction relative to the direction of the rotational axis 6 in comparison with the blade force B. Owing to this change in orientation of the blade force, the flow in the vicinity of the trailing edge portion 3t obtains a momentum which directs in the outer radial direction and the flow in the vicinity of the blade tip portion 5 is directed in the outer radial direction. Consequently, the velocity in the vicinity of the blade outlet is made uniform. Since the mixing loss of the blade wake is reduced by velocity uniformity, the efficiency is increased.

[0037] Incidentally, although in Fig. 9, the trailing edge portion 3t is formed to be convex in the rotation direction, the operation which is the same as the above-mentioned one can be obtained by further linearly changing it in a direction that the curvature of the trailing edge portion 3t is made large relative to the trailing edge portion 3h with the inflection point 18 interposed.

Embodiment 4

[0038] In the present embodiment, an embodiment that the effect of noise reduction can be also obtained in addition to efficiency heightening in the embodiments 1 to 3 will be described using Fig. 10 and Fig. 11.

[0039] Fig. 10 is a diagram of a propeller fan in an embodiment 4. Fig. 10 is the one that a guard is arranged on the blade wake side of the propeller fan in the embodiments 1 to 3. This guard is of the type which is formed into a frame-like shape or a net-like shape so as to pass air to the discharge side of the blade and prevents mixing of the foreign material which exceeds a predetermined size through gaps in the frame or the net. The velocities in the vicinity of the blade outlets of the propeller fans in the embodiments 1 to 3 are made uniform in comparison with that of the conventional propeller fan. Since noise caused by the flow is proportional to the sixth power of a flow rate, the noise generated from a guard 11 is, in a case where the velocity is locally large, the noise generated from that portion becomes predominant. Accordingly, in the present embodiment 3 that the velocity has been made uniform, the noise is reduced in comparison with a combination with the conventional propeller fan.

[0040] One example of comparison in noise of the propeller fan in the embodiment 3 with the conventional propeller fan is shown in Fig. 11. It is confirmed that the noise of the propeller fan in the embodiment 3 is reduced by approximately 1 dB in comparison with that of the conventional propeller fan.

[0041] Incidentally, it is necessary to form the gap in the frame or the net of this guard 11 to be less than a predetermined size such that a finger of an adult does not enter it. Further, it is necessary to make it not to touch a propeller 12 even in a case where a finger of a child has entered the gap in the guard 11. Therefore, further safety can be ensured by setting a distance L from an end portion of the frame or the net of the guard 11 to a position 19 where the trailing edge 3 is closest to the guard 11 so as to exceed a predetermined length. Since it is assumed that the length of the finger of the child is approximately 50 mm, it is desirable to ensure 50 mm or more as the distance L.

Embodiment 5

[0042] In the present embodiment, an air conditioner using a propeller fan equipped with requirements of any of the embodiments 1 to 4 will be described.

[0043] Fig. 12 is a sectional diagram of the air conditioner in an embodiment 5. This air conditioner is an outdoor unit, in Fig. 12, the propeller 12 rotates by being

fixed to and supported by a motor 13, a motor support table 14. The bell mouth 8 is arranged on an outer periphery of the propeller 12. The guard 11 is arranged in a downstream area thereof. A heat exchanger 16 is installed upstream of the propeller 12 in a unit 15. A compressor 17 is loaded in the unit 15.

[0044] This air conditioner is, after air has been sucked into and cooled or overheated by the heat exchanger 16 by rotating the propeller 12 by the motor 13, it is boosted by the propeller 12 and the bell mouth 8 and thereafter is discharged through the guard 11. Since the propeller fan described in any of the embodiments 1 to 4 is used as the propeller fan and the bell mouth, the noise-reduced and highly efficient air conditioner can be obtained.

[0045] Incidentally, although the outdoor unit has been described in the present embodiment, the present invention is a technology which can be commonly used in the ones using the propeller fan regardless of whether the air conditioner is of another type and an indoor unit. Reference Signs List

[0046]

1, 1': blade
2, 2': hub
3, 3', 3t, 3h: trailing edge portion
4, 4': leading edge portion
5, 5': blade tip portion
6, 6': center of rotation
7: inflection point
8: bell mouth
9: cylindrical potion
10, 10a, 10b: end portion
11: guard
12: propeller
13: motor
14: motor support table
15: unit
16: heat exchanger
17: compressor
18: inflection point
19: position where the trailing edge 3 is closest to the guard 11 from the end portion of the frame or the net of the guard 11
A, A': blade force
B: blade force
C: blade force
L: distance
S: flow
T: flow
U: flow
X: air flowing direction
Y: rotation direction
α: first curvature
β: second curvature

Claims

1. A propeller fan, comprising:

a rotational axis serving as a center of rotation; and
a plurality of blades provided around the rotational axis,
a bell mouth being arranged outside in an outer radial direction of the plurality of blades, wherein each of the plurality of blades is formed by
a trailing edge portion formed on the rear relative to a rotation direction, a leading edge portion formed on the front relative to the rotation direction, a blade tip portion formed from a tip portion in an outer radial direction of the trailing edge portion toward a tip portion in an outer radial direction of the leading edge portion,
the trailing edge portion which has been rotationally projected on a plane passing through the rotational axis is formed from the rotational axis toward the blade tip portion so as to bend from the suction side to the discharge side with a first curvature, and further is formed so as to bend with a second curvature which is smaller than the first curvature with an inflection point interposed.

2. The propeller fan according to claim 1, wherein
on an end face of the bell mouth which is closest to the blade, a position which is an end portion in a discharge direction and where an angle is changed in an outer radial direction almost matches a position of the inflection point, viewing from above a rotation plane.

3. The propeller fan according to claim 1, wherein
the trailing edge portion which has been rotationally projected on a plane vertical to the rotational axis is formed to be convex in a reverse rotation direction from the rotational axis toward the blade tip portion, and is formed linearly or to be convex in the rotation direction with the inflection point interposed.

4. The propeller fan according to any of claims 1 to 3, wherein
each of the plurality of blades is,
a blade force acts on a part formed with the first curvature in the trailing edge portion so as to direct in an outer radial direction relative to a direction of the rotational axis and a blade force acts on a part formed with the second curvature in the trailing edge portion so as to direct in an inner radial direction relative to the direction of the rotational axis.

5. The propeller fan according to any of claims 1 to 3, comprising:

a guard which lets air pass toward the discharge side of the blade, prevents mixing of a foreign material which exceeds a predetermined size and is apart from the propeller with a distance exceeding a predetermined length.

6. An air conditioner, comprising:

a housing having a suction port and a discharge port of air;
a heat exchanger arranged in the housing; and
a fan which is arranged upstream or downstream of the heat exchanger and sucks air on the outside of the housing through the suction port and discharges the air through the discharge port, wherein
the propeller fan according to any of claims 1 to 3 has been used as the fan.

FIG. 1

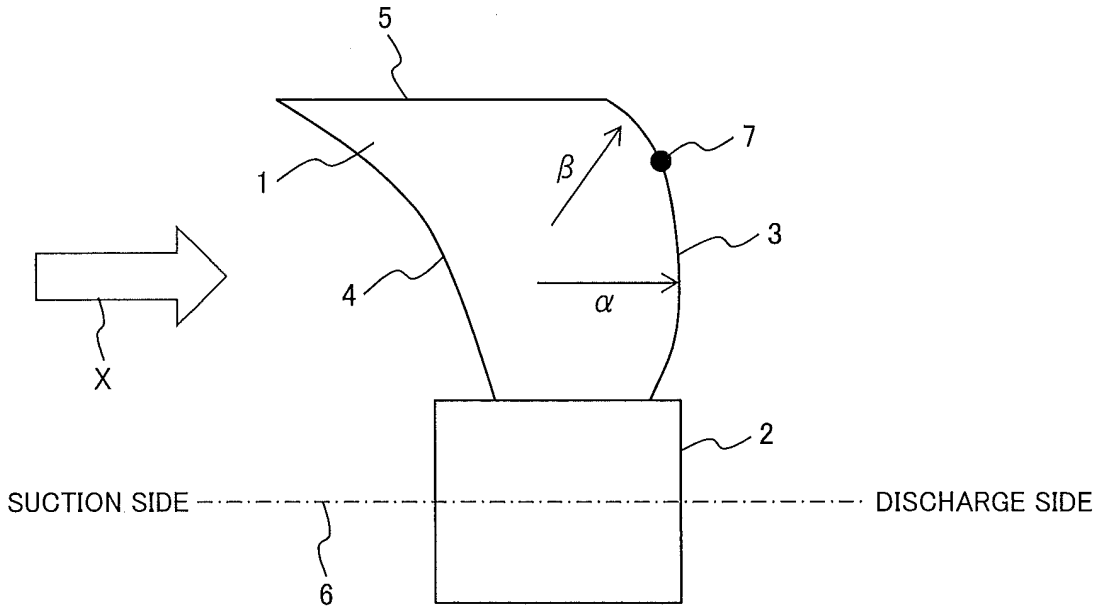
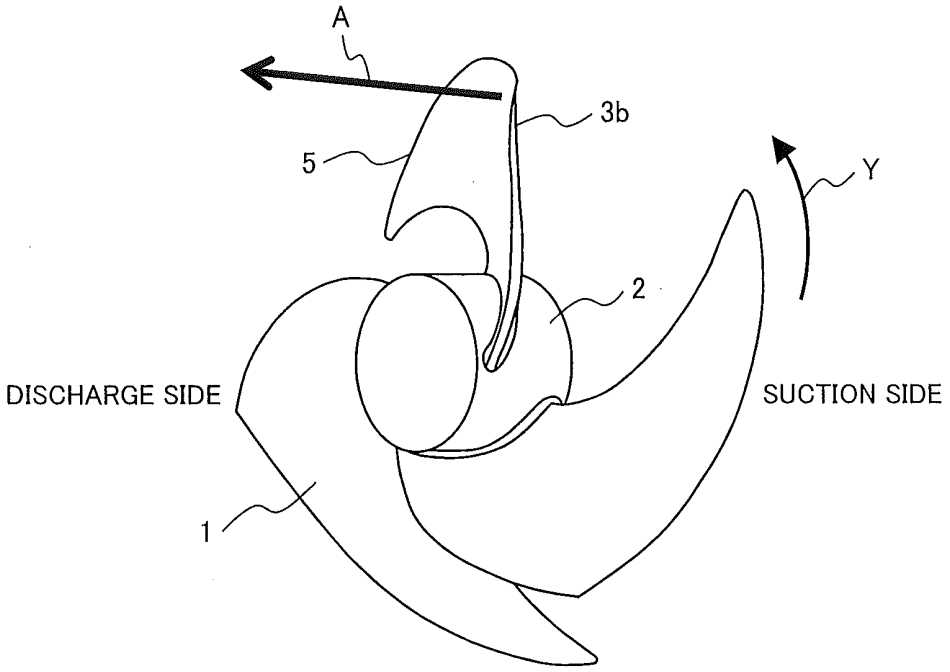
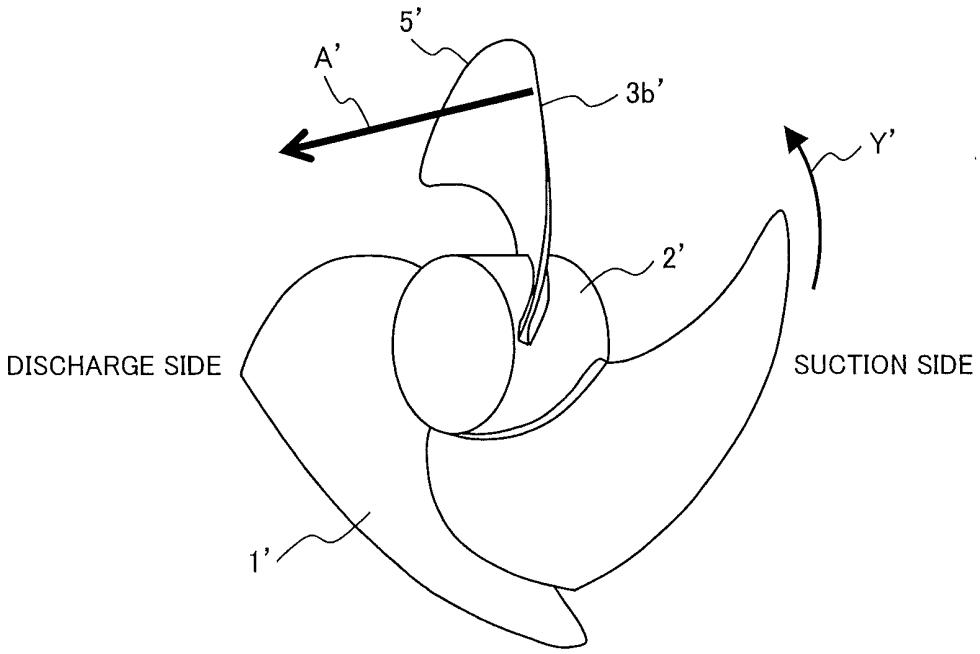


FIG. 2



(a) PRESENT INVENTION



(b) CONVENTIONAL

FIG. 3

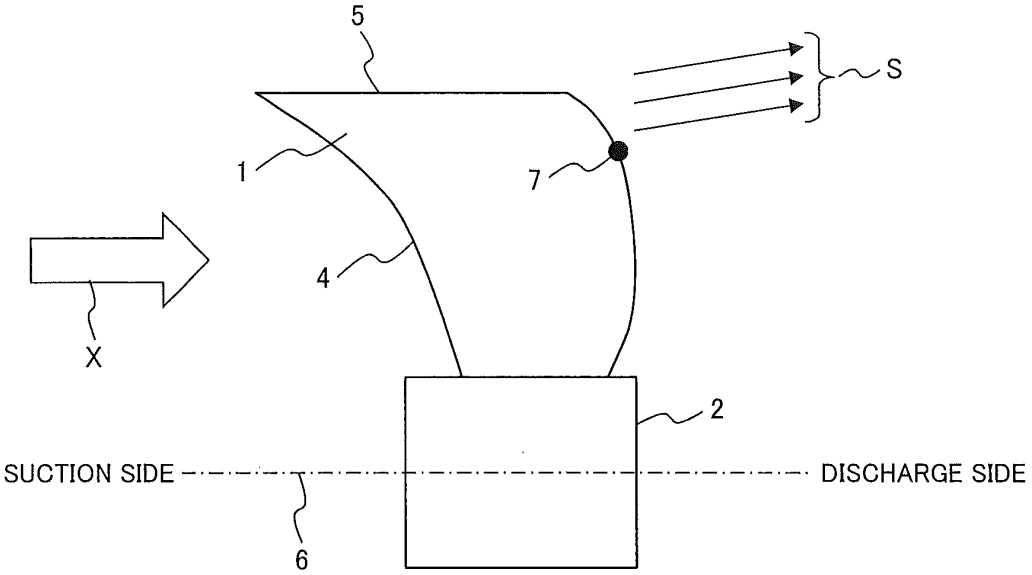
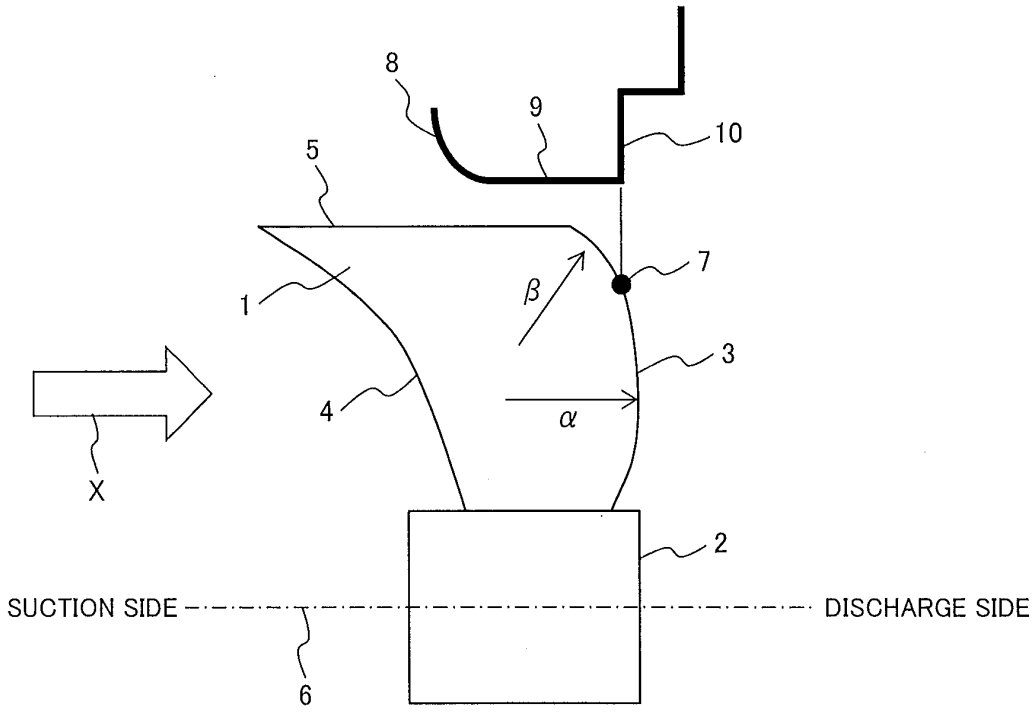

5
S
1
7
4
X
2
SUCTION SIDE
DISCHARGE SIDE
6

FIG. 4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SUCTION SIDE
DISCHARGE SIDE
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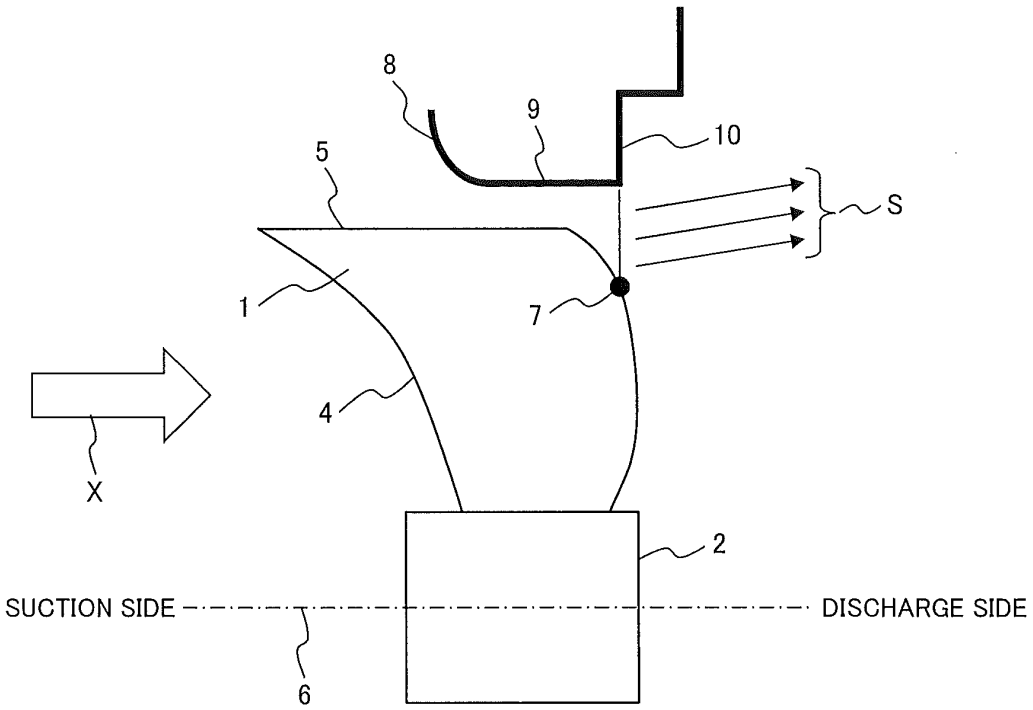
FIG. 5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SUCTION SIDE
DISCHARGE SIDE
6

FIG. 6

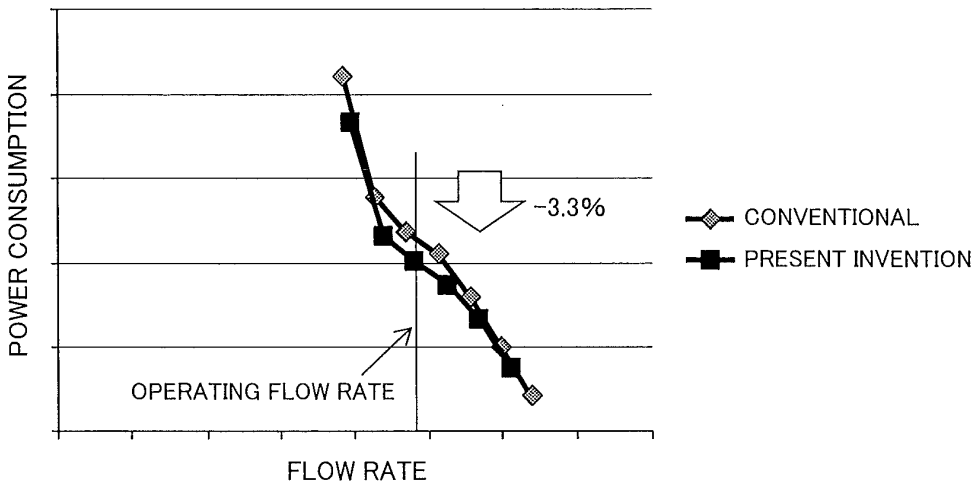

POWER CONSUMPTION
-3.3%
CONVENTIONAL
PRESENT INVENTION
OPERATING FLOW RATE
FLOW RATE

FIG. 7

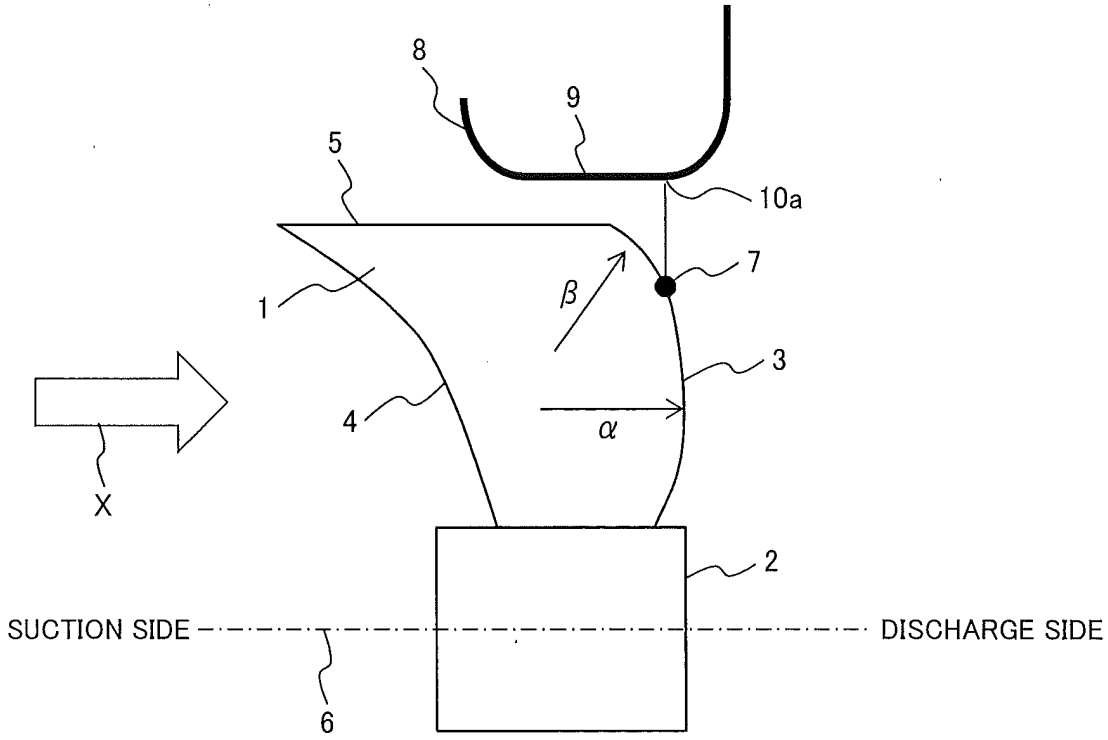
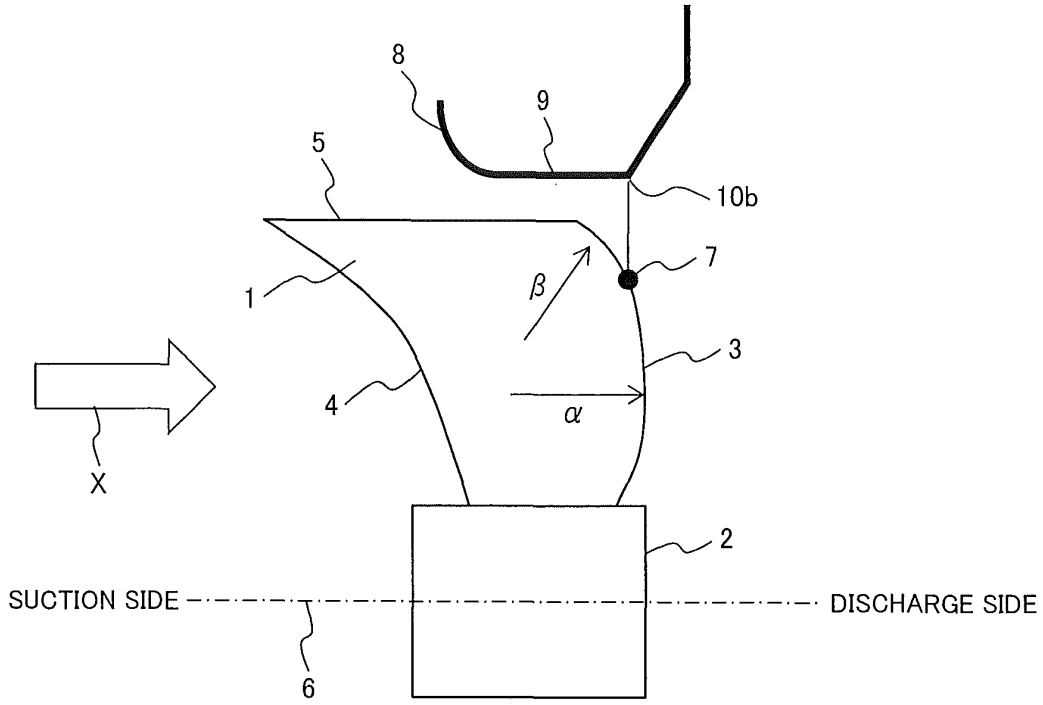


FIG. 8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9
5
10b
7
β
1
3
4
α
X
2
SUCTION SIDE
DISCHARGE SIDE
6

FIG. 9

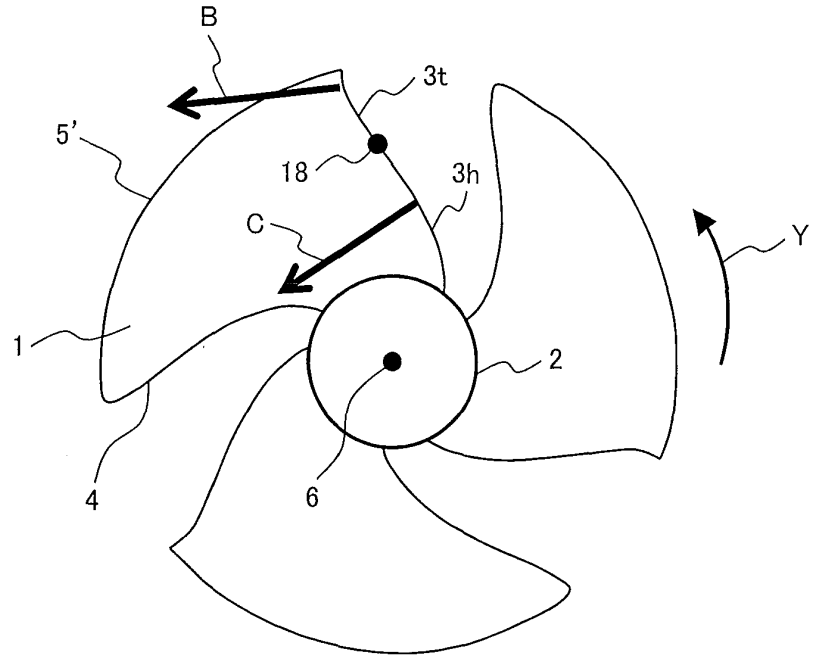

B
3t
5'
18
3h
C
Y
1
2
4
6

FIG. 10

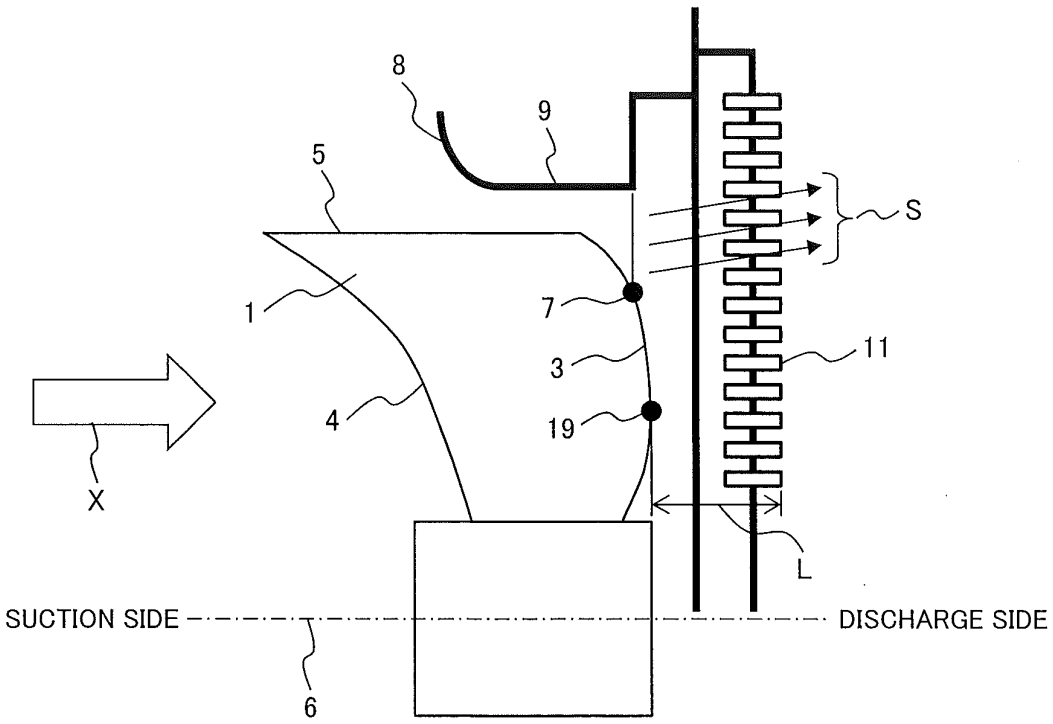

8
9
5
S
1
7
11
3
4
19
X
L
SUCTION SIDE
DISCHARGE SIDE
6

FIG. 11

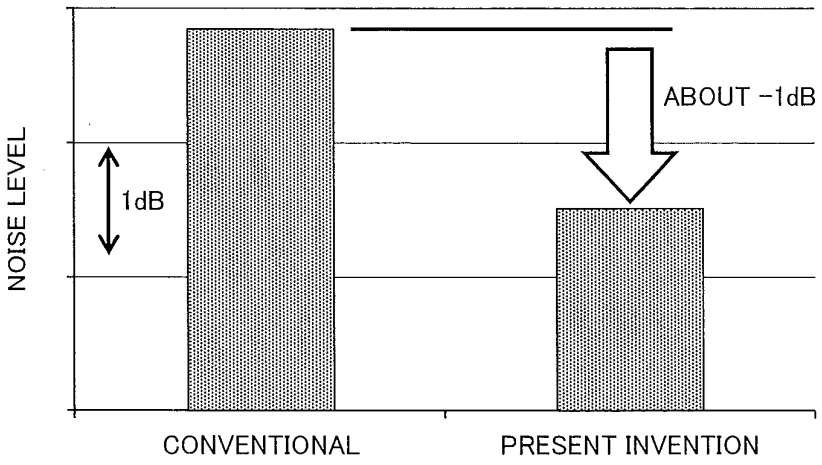

NOISE LEVEL
1dB
ABOUT −1dB
CONVENTIONAL
PRESENT INVENTION

FIG. 12

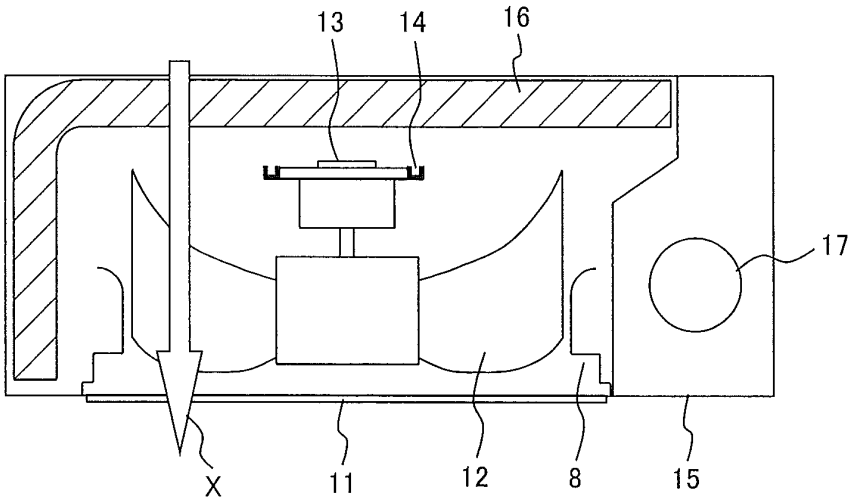


FIG. 13

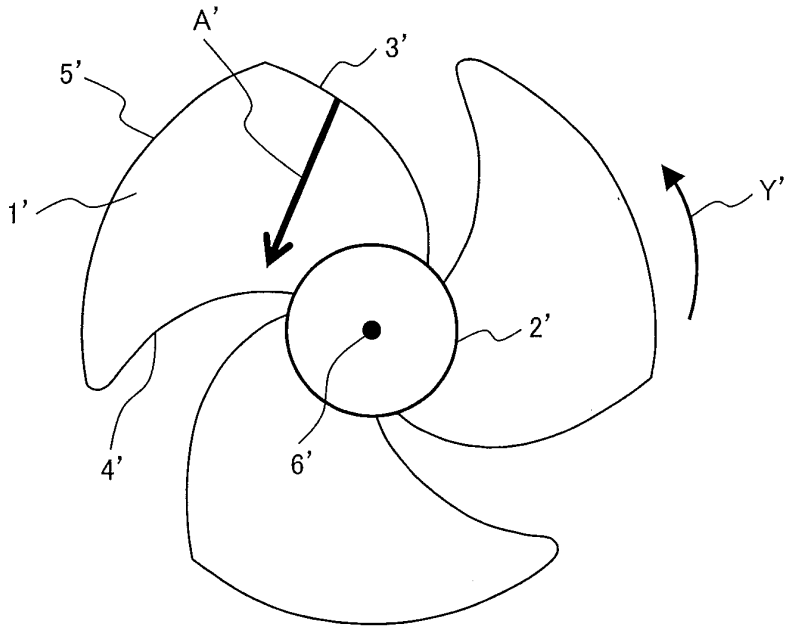
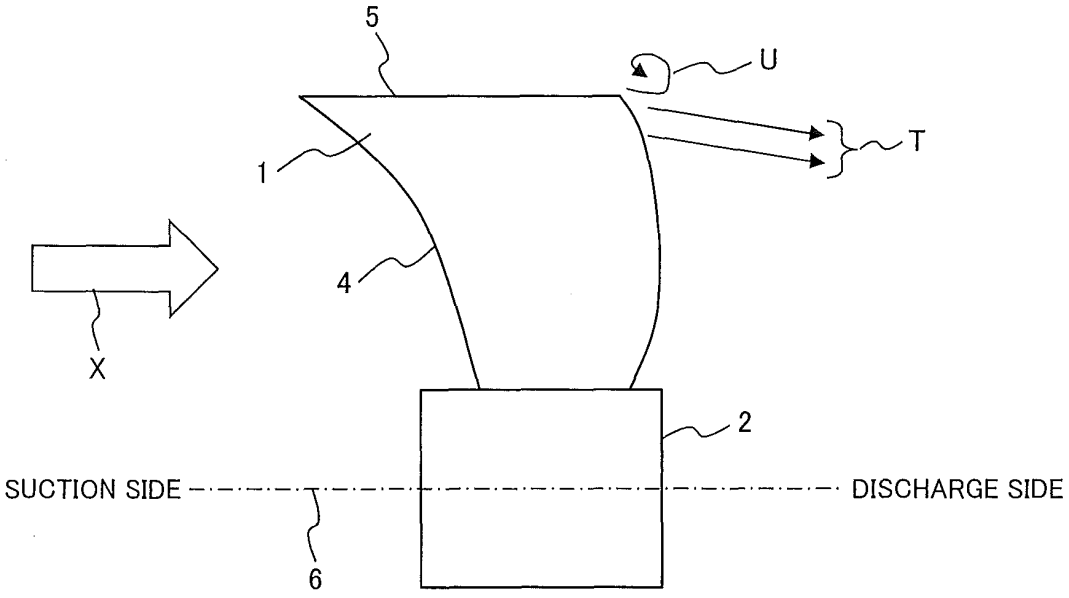


FIG. 14



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/054451

A. CLASSIFICATION OF SUBJECT MATTER
F04D29/38(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04D29/38

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2013
Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 2004-301451 A (Toshiba Carrier Corp.), 28 October 2004 (28.10.2004), entire text; all drawings & EP 1610068 A1 & WO 2004/088210 A1 & KR 10-2005-0120678 A & CN 1768237 A & CN 101025281 A	1,3,5,6 2,4
A	JP 2002-257088 A (Toshiba Carrier Corp.), 11 September 2002 (11.09.2002), fig. 5, 6 & KR 10-2002-0071756 A & CN 1374460 A	1-6
A	JP 2006-2584 A (Samsung Electronics Co., Ltd.), 05 January 2006 (05.01.2006), entire text; all drawings & KR 10-2005-0119070 A & CN 1712734 A	1-6

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed
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Date of the actual completion of the international search	Date of mailing of the international search report
04 June, 2013 (04.06.13)	11 June, 2013 (11.06.13)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/054451

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 7125220 B2 (SUNONWEALTH ELECTRIC MACHINE INDUSTRY CO.), 24 October 2006 (24.10.2006), fig. 6 & TW 256444 B	1-6
A	JP 10-501867 A (Valeo Thermique Moteur), 17 February 1998 (17.02.1998), entire text; all drawings & US 5616004 A & EP 766791 A & WO 1996/033345 A1 & CN 1150834 A	1-6
A	JP 2000-274912 A (Mitsubishi Electric Corp.), 06 October 2000 (06.10.2000), claim 1; all drawings (Family: none)	1-6

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP HEI22000 B **[0003] [0006]**
- JP 3744489 B **[0004] [0006]**
- JP 4818184 B **[0005] [0006]**